

App. No. 10/621,981

Reply to final Office Action of May 26, 2006

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Amendments to the Claims:

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1. (previously presented) A thermal barrier coating for coating a substrate, comprising:

a bond coating layer disposed on a surface of said substrate;

a segmented columnar ceramic layer disposed on said bond coating layer, said segmented columnar ceramic layer comprising a layer of stabilized zirconia disposed on said bond coating layer, a layer of stabilized hafnia disposed on said layer of stabilized zirconia, and a transition region between the layers of stabilized zirconia and the stabilized hafnia in which a stabilized zirconia concentration decreases and a stabilized hafnia concentration increases along a transition gradient, said ceramic layer having a plurality of adjacent columns formed substantially therethrough and a plurality of segmentation gaps between the adjacent columns; and

a structure-stabilizing material disposed within said plurality of segmentation gaps between the adjacent columns.

2. (original) The thermal barrier coating of claim 1, wherein said segmented columnar ceramic layer comprises a layer of yttria stabilized hafnia.

3. (original) The thermal barrier coating of claim 1, wherein said structure-stabilizing material is a reaction product formed by reacting a first sol gel component with a second sol gel component.

4. (original) The thermal barrier coating of claim 1, wherein said layer of stabilized hafnia includes a stabilizing oxide component, and said structure-stabilizing material is a reaction product formed by reacting a sol gel component with said stabilizing oxide component.

App. No. 10/621,981  
Reply to final Office Action of May 26, 2006

5. (original) The thermal barrier coating of claim 1, wherein said structure-stabilizing material comprises particles of an yttrium aluminum oxide.

6. (original) The thermal barrier coating of claim 1, wherein said structure-stabilizing material is insoluble in said layer of stabilized hafnia at a temperature of at least about 3400°F.

7. (original) The thermal barrier coating of claim 1, wherein said structure-stabilizing material is selected from the group consisting of  $\text{YAlO}_3$ ,  $\text{Y}_3\text{Al}_5\text{O}_{12}$ , and  $\text{Y}_4\text{Al}_2\text{O}_9$ .

8. (original) The thermal barrier coating of claim 1, further comprising a sealant layer disposed on said layer of stabilized hafnia, said sealant layer sealing said plurality of segmentation gaps.

9. (original) The thermal barrier coating of claim 8, wherein said layer of stabilized hafnia comprises yttria stabilized hafnia.

10. (original) The thermal barrier coating of claim 8, wherein said sealant layer comprises a continuous, non-segmented layer of cubic yttria stabilized hafnia or a continuous, non-segmented layer of cubic yttria stabilized zirconia.

11. (original) The thermal barrier coating of claim 8, wherein said sealant layer has a thickness in the range of from about 0.5 to 10 mils.

App. No. 10/621,981

Reply to final Office Action of May 26, 2006

12. (original) The thermal barrier coating of claim 1, wherein said layer of stabilized hafnia comprises cubic yttria stabilized hafnia and has a thickness in the range of from about 10 to 60 mils.

13. (canceled).

14. (previously presented) The thermal barrier coating of claim 1, wherein said layer of stabilized zirconia comprises a layer of yttria stabilized zirconia, and said layer of stabilized hafnia comprises a layer of yttria stabilized hafnia.

15 to 16. (canceled).

17. (previously presented) A thermal barrier coating for coating a substrate, comprising:  
a bond coating layer disposed on a surface of said substrate;  
a first segmented columnar ceramic layer comprising yttria stabilized zirconia disposed on said bond coating layer;  
a second segmented columnar ceramic layer comprising yttria stabilized hafnia disposed on said first segmented columnar ceramic layer, each of said first segmented columnar ceramic layer and said second segmented columnar ceramic layer having a plurality of segmentation gaps therein;

App. No. 10/621,981  
Reply to final Office Action of May 26, 2006

a transition region between the layers of the yttria stabilized zirconia and the yttria stabilized hafnia in which a stabilized zirconia concentration decreases and a stabilized hafnia concentration increases along a transition gradient;

a structure-stabilizing material disposed within said plurality of segmentation gaps, wherein said structure-stabilizing material stabilizes said first segmented columnar ceramic layer and said second segmented columnar ceramic layer; and

an outer sealant layer disposed on said second segmented columnar ceramic layer, said outer sealant layer comprising a continuous, non-segmented ceramic layer, and said outer sealant layer sealing said plurality of segmentation gaps within said second segmented columnar ceramic layer.

18. (original) The thermal barrier coating of claim 17, wherein said plurality of segmentation gaps within said first segmented columnar ceramic layer are substantially aligned with said plurality of segmentation gaps within said second segmented columnar ceramic layer.

19. (original) The thermal barrier coating of claim 18, wherein said structure-stabilizing material is insoluble in said second segmented columnar ceramic layer when said second segmented columnar ceramic layer is exposed to a temperature of about 3400°F.

20. (original) The thermal barrier coating of claim 17, wherein said first segmented columnar ceramic layer comprises cubic yttria stabilized zirconia, and said second segmented columnar ceramic layer comprises cubic yttria stabilized hafnia.

21. (original) The thermal barrier coating of claim 20, wherein the thickness of said second segmented columnar ceramic layer is selected such that a temperature gradient transition

App. No. 10/621,981  
Reply to final Office Action of May 26, 2006

within said thermal barrier coating from said cubic yttria stabilized zirconia to said cubic yttria stabilized hafnia occurs at a temperature of less than about 2900°F.

22. (previously presented) A thermal barrier coating for coating a substrate, comprising:
  - a bond coating layer disposed on a surface of said substrate;
  - a layer of cubic yttria stabilized zirconia disposed on said bond coating layer, said layer of cubic yttria stabilized zirconia comprising from about 7 to 40 mole % yttria and from about 60 to 93 mole % zirconia, and having a thickness in the range of from about 5 to 60 mils;
  - a layer of cubic yttria stabilized hafnia disposed on said layer of cubic yttria stabilized zirconia, said layer of cubic yttria stabilized hafnia being thinner than the layer of cubic yttria stabilized zirconia and having a thickness in the range of from about 5 to 50 mils, each of said layer of cubic yttria stabilized hafnia and said layer of cubic yttria stabilized zirconia having a columnar microstructure and a plurality of segmentation gaps within said columnar microstructure, said plurality of segmentation gaps oriented substantially orthogonal to said surface of said substrate;
  - a structure-stabilizing material disposed within said plurality of segmentation gaps in the layers of cubic yttria stabilized zirconia and cubic yttria stabilized hafnia, said structure-stabilizing material comprising particles of an yttrium aluminum oxide, said particles having a diameter in the range of from about 0.1 to 2 microns; and
  - an outer sealant layer disposed on said layer of cubic yttria stabilized hafnia, said outer sealant layer comprising a continuous, non-segmented coating on said columnar microstructure, and said outer sealant layer sealing said plurality of segmentation gaps within said layer of cubic yttria stabilized hafnia, said outer sealant layer comprising a material selected from the group consisting of cubic yttria stabilized zirconia and cubic yttria stabilized hafnia.

App. No. 10/621,981  
Reply to final Office Action of May 26, 2006

23. (previously presented) In a thermal barrier coating including a bond coating layer, a first segmented columnar ceramic layer on the bond coating layer, and a structure-stabilizing material interposed between columns of said first segmented columnar ceramic layer, the improvement which comprises:

a second segmented columnar ceramic layer disposed on said first segmented columnar ceramic layer, said second segmented columnar ceramic layer being thinner than the first segmented columnar ceramic layer and comprising yttria stabilized hafnia, wherein said structure-stabilizing material is also interposed between columns of the second segmented columnar layer and is insoluble therein at a temperature of at least about 3400°F.

24. (original) The thermal barrier coating of claim 23, wherein said second segmented columnar ceramic layer and said first segmented columnar ceramic layer resist sintering when an outer surface of said thermal barrier coating is exposed to a temperature of at least about 3400°F.

25. (original) The thermal barrier coating of claim 23, wherein said second segmented columnar ceramic layer comprises cubic yttria stabilized hafnia and said first segmented columnar ceramic layer comprises cubic yttria stabilized zirconia.

26. (original) The thermal barrier coating of claim 23, further comprising a continuous, non-segmented ceramic sealant layer disposed on said second segmented columnar ceramic layer, wherein said sealant layer comprises a material selected from the group consisting of cubic stabilized zirconia and cubic stabilized hafnia.

App. No. 10/621,981  
Reply to final Office Action of May 26, 2006

27. (original) The thermal barrier coating of claim 26, wherein said sealant layer comprises a material selected from the group consisting of cubic yttria stabilized zirconia and cubic yttria stabilized hafnia.

28. (original) The thermal barrier coating of claim 23, wherein said sealant layer prevents penetration of glassy dust or salt deposits into said thermal barrier coating, and said thermal barrier coating promotes the elimination of glassy dust and salt deposits from said thermal barrier coating.

29. (previously presented) An article of manufacture for a gas turbine engine, comprising:

a superalloy substrate;

a bond coating layer disposed on said substrate;

a first segmented columnar ceramic layer comprising yttria stabilized zirconia disposed on said bond coating layer;

a second segmented columnar ceramic layer comprising yttria stabilized hafnia disposed on said first segmented columnar ceramic layer, each of said first segmented columnar ceramic layer and said second segmented columnar ceramic layer having a plurality of segmentation gaps therein, said plurality of segmentation gaps interspersed with and defining a plurality of columns within said first and second segmented columnar ceramic layers;

a transition region, between the first and second segmented columnar ceramic layers, in which stabilized zirconia concentration decreases and a stabilized hafnia concentration increases along a transition gradient;

a structure-stabilizing material disposed within said plurality of segmentation gaps, wherein said structure-stabilizing material maintains the integrity of said plurality of columns

App. No. 10/621,981  
Reply to final Office Action of May 26, 2006

within said first segmented columnar ceramic layer and said second segmented columnar ceramic layer; and

an outer, continuous, non-segmented sealant layer disposed on said second segmented columnar ceramic layer, said sealant layer preventing penetration of extraneous materials into said plurality of segmentation gaps.

30. (original) The article of manufacture of claim 29, wherein said structure-stabilizing material comprises particles of an yttrium aluminum oxide, said particles interposed between adjacent members of said plurality of columns, said particles having a diameter in the range of from about 0.1 to 2 microns.

31. (original) The article of manufacture of claim 29, wherein said bond coating layer is selected from the group consisting of an aluminide and a MCrAlY, wherein M is a metal selected from the group consisting of nickel, cobalt, and mixtures thereof.

32 to 46. (canceled).